Barriers and Enablers of Innovation: A Pilot Survey of Transportation Professionals

Lawrence H. Orcutt
(primary author)
Chief, Division of Research and Innovation
California Department of Transportation
1227 'O' Street, 5th Floor
Sacramento, CA 95814

(916) 654-8877 voice
(916) 657-4677 fax
Larry_Orcutt@dot.ca.gov

Mohamed Y. AlKadri, Ph.D., PE
(corresponding author)
Chief, Research Evaluation and Decision Support Branch
Division of Research and Innovation
California Department of Transportation
and
Visiting Scholar
California PATH Program
University of California, Berkeley
1357 S. 46th Street, Building 457
Richmond, CA 94804

(510) 665-3429 voice
(510) 665-3443 fax
alkadri@PATH.Berkeley.edu

A TRB manuscript submitted for peer review and for the 2009 Compendium of Papers and possible publication in the *Transportation Research Record*

Word count = 4620 words plus 8 figures and 1 table

Barriers and Enablers of Innovation: A Pilot Survey of Transportation Professionals

ABSTRACT

In this research, a small sample of 109 transportation professionals was surveyed to document their experiences with a set of common barriers and enablers of innovation. About 76%, of the participants were transportation practitioners and researchers from California. The remaining 24% were DoT research executives from other states. Of the California participants, 84% were employees at the California Department of Transportation (Caltrans). The sample was fairly evenly distributed among professional ranks with 39% rank and file, 15% supervisors, 23% middle managers, and 23% executives.

The survey asked the participants whether they considered revolutionary (disruptive) or evolutionary (sustaining) innovation is more critical; how to rate common roadblocks and enablers to innovation; which of the areas of safety, performance, cost-effectiveness, quality, and environment innovation is most important; and finally what steps they suggest to improve the process of innovation.

Research findings are described and documented in this paper. Findings indicate that respondents are highly in favor of innovation. About 63% respondents considered themselves champions of innovation. An impressive 99% of respondents rated innovation as "important" or "very important." Preference for revolutionary vs. evolutionary innovations varied with 73% of academic respondents stating focus should be on revolutionary innovation and only 27% of non-academic respondents indicating so. The worst-rated innovation roadblock was "resistance to change." The highest-rated enabler of innovation was "product matched user need." Respondents provided specific suggestions to improve innovation by establishing clear direction and procedures, securing executive sponsorship, empowering people to innovate, and finding champions for innovation at all levels.

RESEARCH MOTIVATION

Research Background

Research work leading to this paper was conducted at the Division of Research and Innovation (DRI) at the California Department of Transportation (Caltrans). With its staff of 85 planners, engineers and research analysts and an annual budget of $45 million, DRI is one of the largest state transportation research programs in the US.

This research was largely motivated by desire of the authors to share lessons learned in the implementation of innovation. The primary author of this paper has led DRI over the past five years and previously was Chief of Caltrans Division of Maintenance (a division with over 6000 employees and an annual budget of one billion dollars, a good portion of which is spent on implementing innovative tools and methods). Caltrans has faced and often successfully managed numerous challenges in transforming research products into deployable working systems. DRI did so by participating in innovative projects that produced advanced transportation systems, products, and services such as the National Intelligent Transportation System Architecture (NITSA), Automated Highway Systems (AHS), Intelligent Vehicle Initiative, (IVI), Bus Rapid

Transit (BRT), Integrated Corridor Management Initiative (ICMI), and Cooperative Intersection Collision Avoidance Systems.

Over its 22-year history, in order to solve transportation problems in California and advance the state of knowledge and practice in transportation as a whole, DRI has funded and supervised advanced transportation research at University of California campuses at Berkeley, Davis, Irvine, Los Angeles, Riverside, and Santa Barbara. DRI has also funded and managed research at California State University at campuses at Long Beach, Sacramento, San Diego, CalPoly San Louis Obispo, and San Jose. DRI has also funded and conducted research in collaboration with research institutions in and outside California including Stanford University, University of Southern California, George Mason University, Virginia Tech, Texas A&M University, University of Michigan, Carnegie Mellon University, University of North Carolina, Chapel Hill and many other research institutions and the National Labs. DRI exchanged staff and expertise with, among others, Montana Western Transportation Institute, Texas Transportation Institute, ITS Japan, and INRETS France.

DRI learned that partnerships can the implementation of innovation. Therefore, to move research products towards deployment, DRI has formed partnerships with major implementers and operators at the state and regional levels such as the Bay Area Metropolitan Transportation Commission, Los Angeles Metropolitan Transportation Authority (LAMTA), California Highway Patrol (CHP), California Alliance for Advanced Transportation Systems (CAATS), Bay Area Rapid Transit (BART), the Santa Clara Valley Transit Authority, Southern California Association of Governments (SCAG), and other local and city governments and public entities.

Finally, to facilitate commercialization of innovative research products, DRI helped establish the California Center for Innovative Transportation (CCIT) at UC Berkeley. DRI has been working with private sector developers and manufactures such as General Motors, DaimlerChrysler, Ford Motor Company, Honda, Toyota, Cambridge Systematics, Rockwell International, Hughes Aircraft, Lockheed Martin, Honeywell, TRW, Booz, Allen and Hamilton, and the Chevron Research Corporation and numerous other private sector R&D entities.

In this paper, the authors tapped into the vast depository of experience, lessons learned, and challenges still being encountered at DRI in particular and Caltrans overall to formulate their research questions.

Research Objectives

The objectives of research leading to this paper have been 1) to determine whether transportation managers should focus on sustaining (evolutionary) innovation or disruptive (revolutionary) innovation; 2) to identify the most common roadblocks facing the implementation of innovation, particularly at an organization like Caltrans; 3) to identify the most common enablers (or "boosters") of the innovation process; 4) to prioritize the importance of innovation in safety, performance, cost-effectiveness, quality, and environmental protection; and finally, 5) to identify new ways to help facilitate the process of implementing innovation at Caltrans in particular and at other state departments of transportation in general.

Research Methodology

The authors used two approaches to answer these questions. The first was to develop case studies of innovative projects and analyze roadblocks encountered and mitigation measures used. That effort is described in another paper submitted to the TRB titled "*Overcoming Roadblocks Facing the Implementation of Innovations: Analysis of Three Case Studies at Caltrans*." The second approach was to use a survey based on a review of relevant literature (**1**) as well as the authors' own experiences. The authors compiled and analyzed a list of the major *roadblocks* as well as *enablers* along the road to implementing innovation. The authors assume that they have identified all significant roadblocks and boosters of innovation. The authors defined *Sustaining Technology* as one that includes changes that improve our current business practices or products. Incremental performance improvements result from sustaining technologies. They defined *Disruptive Technology* as one that includes changes that completely reorient how business is conducted. Based on suggestions in the literature **(1, 2)** and their own experience, authors identified five areas in need of innovation: Safety, performance, cost-effectiveness, quality, and environmental protection as candidate areas for innovation. Lastly, the authors accepted conclusions reached by AlKadri et al that the implementation of even revolutionary transportation innovations such as the Automated Highway Systems (AHS) needs to take place in a modular and incremental manner (**3**). AlKadri et al argued that revolutionary deployment does not always allow for the adequate (long-term) testing of technology and ignores the challenges of market acceptance and social change (**3**).

Collectively, the above assumptions constituted a "hypothesis" that has been tested with the survey. Respondents rated the importance and impacts of each of these roadblocks and enablers. Respondents were asked which innovation approach (sustaining or disruptive) is more preferred and how to prioritize innovation in the five areas of safety, performance, cost-effectiveness, quality, and environmental protection. Finally, the authors asked the participants to provide suggestions on how to improve the process of innovation. Only descriptive statistics are used in this exploratory analysis of the data.

SURVEY INSTRUMENT

Survey Questions

The survey instrument consisted of ten questions. At the start of the survey, the word "innovation" was defined to establish the context of this research. Participants were informed that, for the purpose of this survey, the following definition for innovation is proposed:

> "Innovation is the successful implementation of a new and widely-used product or business practice. Innovation in the highway sector usually involves products or business practices that improve performance, cost-effectiveness, quality, safety, and/or reduce environmental consequences."

Table I contains a list of these questions. The first two questions were used to collect information about the background and affiliation of respondents. Questions 3, 7, 8, and 9 were "evaluation questions through which respondents would rate the importance/significance of each roadblock or enabler. Questions 4 and 6 were multiple-choice questions that asked respondents to choose one or more answers. Question 5 was to assign priority to the five areas in need of innovation (safety, performance, cost-effectiveness, quality, and environmental protection). Question 10 was designed to solicit written comments and suggestions on how to better implement the process of innovation. Table I shows questions 2 through 10 and an explanation of the purpose of each question.

TABLE I Survey Questions

Q#	Question	Purpose
1	(This question requested some identifying information about respondents)	Establish background information for data management purposes
2	**What is your level in your organization?**	Obtain information about respondent's level of responsibility
3.	**Based on the definition provided above, how important is innovation?** (a)	Identify respondent's view on importance of innovation
4.	**Which type of innovation do you think is more important?**	Identify respondent's view on importance of evolutionary vs. revolutionary innovation
5.	**What areas of innovation are you most interested in improving?** (Each is assigned priority from 1-5)	Identify highest-lowest area of importance for innovation to be applied
6.	**What role(s) do you have in implementing innovation?**	Determine proportion of "innovation champions" and identify respondent's role in implementing innovation
7.	**Rate the importance of the roadblocks to innovation listed below.** (a)	Determine which roadblocks respondent sees as serious.
8.	**Rate the implementation boosters that would promote innovation with regard to importance** (a)	Determine which factors respondent believes would facilitate innovation.
	Note: Question 9 will be discussed before Question 8 because it deals with institutional barriers. Question 8, factors that boost innovation will be discussed afterwards.	
9.	**Rate the following in terms of their importance as institutional barriers to implementing innovations** (a)	Determine which institutional factors respondent believes would impede innovation.
10.	**What can be done to improve how innovations are implemented?** Comments and suggestions to be provided by respondents	Requests written recommendations from respondents on how to implement innovation

(a) Ordinal ratings between 1-5 were used.

Sample Population

The questionnaire was sent to 150 transportation professionals. The rate of return was an acceptable 73% with a total of 109 completing and returning useable surveys. Although the sample size is small relative to the universe of all transportation managers, it was selected to be fairly representative of those transportation professionals who are involved in research and innovation. Participants were chosen carefully to obtain a cross-section of planners and engineers, rank-and-file and management, private sector consultants and government agencies, educators and field practitioners from California and across the United States and some from Alberta, Canada. Authors surveyed professionals from outside California to learn from experiences of other state DoTs. All respondents reported high levels of education and extensive experience in the field of transportation research and development.

The survey was sent to all 50 state DoT research directors. There were 26 respondents from outside California (AR, AZ, CO, IA, IL, IN, KS, KY, LA, MD, ME, MN, MO, MT, NE, NV, NY, OK, OR, PA, TX, WI, and WY). Since this is a mainly Caltrans-based survey, most participants were from California however. Eighty-one respondents came from California with 69 respondents from Caltrans, 54 came from Caltrans Division of Research and Innovation. Caltrans respondents are denoted in charts as CT. As shown in Figure 1, the breakdown of respondent positions in the sample was 39% rank and file, 15% supervisor, 23% middle manager, and 23% executive-level. A relatively small number, only 12 respondents, were university professors and transportation research centers affiliated with educational institutions and are denoted in charts as EDU. The small proportion of the academic group in this sample should be kept in mind when making generalized conclusions. Almost 60% of respondents (64 people) provided written suggestions on how to improve the innovation implementation process.

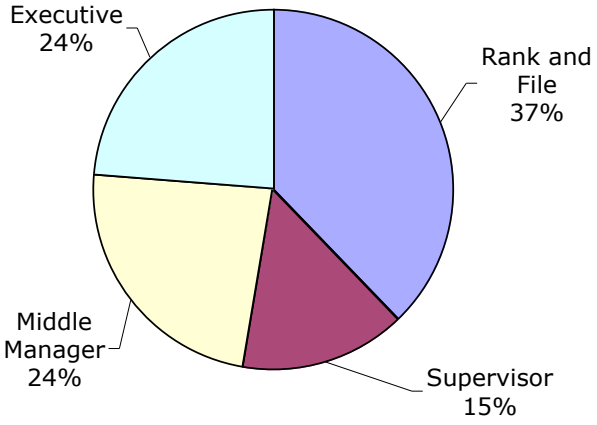

Figure 1. Respondents' positions in their organizations.

Data Collection

The survey was designed using tools form SurveyMonkey.com, a professional web-based survey service. Respondents were given a link to the survey and all answers were collected on-line. The survey was conducted during April and May 2008.

Reference to Respondent Answers

Each respondent was given a number from 1 to 109. In this paper, when a reference is made to a particular answer, statement or comment made by a respondent, it is followed by the letter R and respondent number. For example, a comment made by respondent 65 is followed by (R65) to refer to that respondent. A list of positions and states of those respondents who were quoted or referred to in this paper is given in Table II. Only position and state are indicated in order to understand the professional and geographic context in which respondents provided answers while no names or affiliations are revealed to maintain anonymity of respondents and confidentiality of their answers.

SURVEY RESULTS

Results of the survey will be presented below for each of the questions individually. The first question was to obtain name, affiliation, and background information about respondents. The second question was to identify the respondent's level in the organization. Results from question 2 were illustrated in Figure 1 above. Questions 3 through 10 are discussed below in detail.

Q3. Based on the definition provided above, how important is innovation?

The purpose of this question was to identify respondents' views on importance of innovation. Other than the 1% of respondents who did not have an opinion, 99% believe in the importance of innovation. About 79% of respondents thought that innovation was "very important" and 20% thought it was "important." No respondent thought it was unimportant or that it was neither important nor unimportant. These results are very reassuring, indicating that there is unanimity on the need to innovate. Figure 2 shows the distribution of respondent answers to this question.

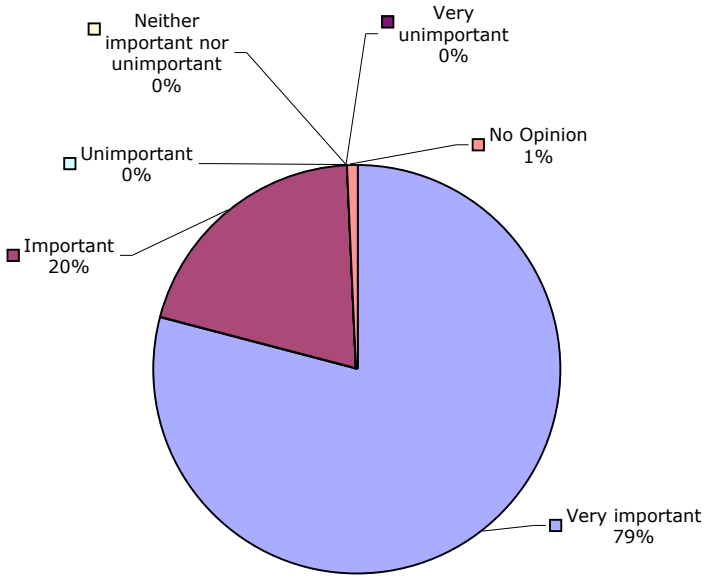

Figure 2. Respondents' views of the importance of innovation.

Q4. Which type of innovation do you think is more important (sustaining or disruptive)**?**

The purpose of this question was to identify respondent's view on importance of evolutionary vs. revolutionary innovation. The questionnaire defined *Sustaining Technology* as one that includes changes that improve our current business practices or products. Incremental performance improvements result from sustaining technologies. It defined *Disruptive Technology* as one that includes changes that completely reorient how business is conducted. For example, in computing the laptop is displacing or marginalizing desktop computing; in photography, digital is displacing or marginalizing film.

Figure 3 shows the proportion of respondents who believed whether sustaining or disruptive innovation technologies as more important. The figure shows all respondents grouped together as well as Caltrans and academic respondents grouped separately to illustrate the different perceptions among practitioners and university researchers. These results may explain some of differences in interest between researchers who want to pursue more basic research and practitioners (and often fund providers and customers) who want the focus to be on applied research. One respondent who is a researcher as well as a field practitioner believed that both sustaining and disruptive are important in their own right.

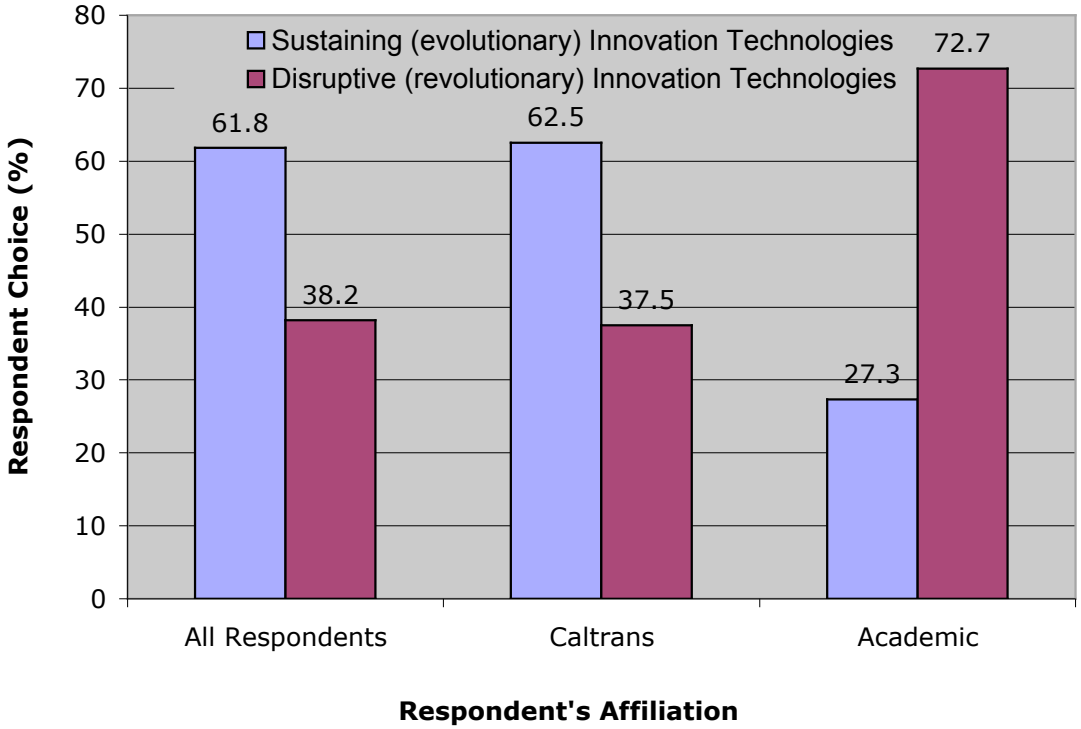

Figure 3. Importance of sustaining vs. disruptive innovations.

Q5. What areas of innovation are you most interested in improving?

The purpose of this question was to ask participants to rank areas where innovation is more important.

Figure 4 shows respondents' average ranking of the five areas. Safety was the top priority for Caltrans respondents. It received an average ranking of 4.1, followed by performance, quality, cost-effectiveness, and finally reducing the impacts on the environment, which received an average of 2.0, lowest level of interest. Academic researchers however indicated they are most interested in performance innovations, followed by quality. Their lowest concern was "cost-effectiveness." These results (with ordinal scores between 1 and 5) also show that the academic researchers seem to be twice as concerned about the environment as are field practitioners.

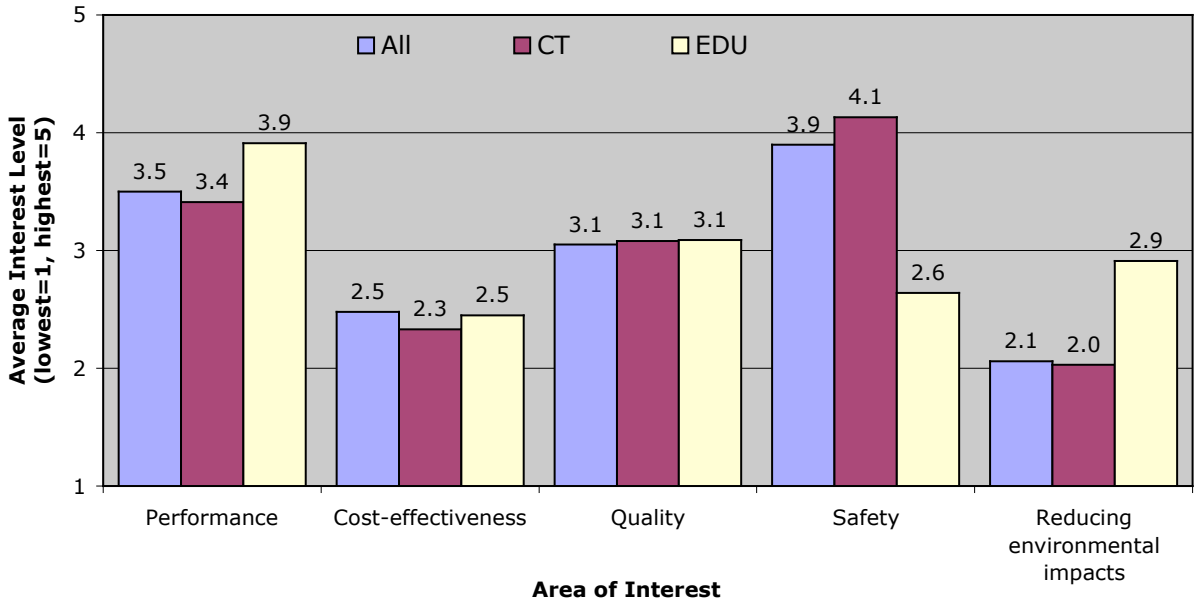

Figure 4. Importance ranking for areas of innovation.

Q6. What role(s) do you have in implementing innovation?

The purpose of this question was to determine proportion of those who considered themselves "innovation champions" and to identify respondents' roles in implementing innovation. The question did not exactly define what makes one a "champion" but it is implied that it is the person who is proactively promoting innovation. Also implied here that champions are *willing to take risks* in order to promote innovation and advance the state of practice in their field.

Figure 5 shows distribution of respondents' roles in the process of innovation. . Almost two-thirds of respondents considered themselves to be innovation champions. As will be shown in later sections, those "risk takers" may explain why "resistance to change" and "risk aversion" were rated as very serious roadblocks to innovation.

It should be noted that the distributions for roles shown in Figure 5 is not cumulative since these roles can overlap. For example, a respondent can be an innovation champion, a decision maker, and play a role in developing policies for implementing innovation all at the same time. Roles 6, 7, 8, and 9 are Caltrans-specific and apply to Caltrans staff only. About 23% of respondents provided some comments about their unique roles in innovation.

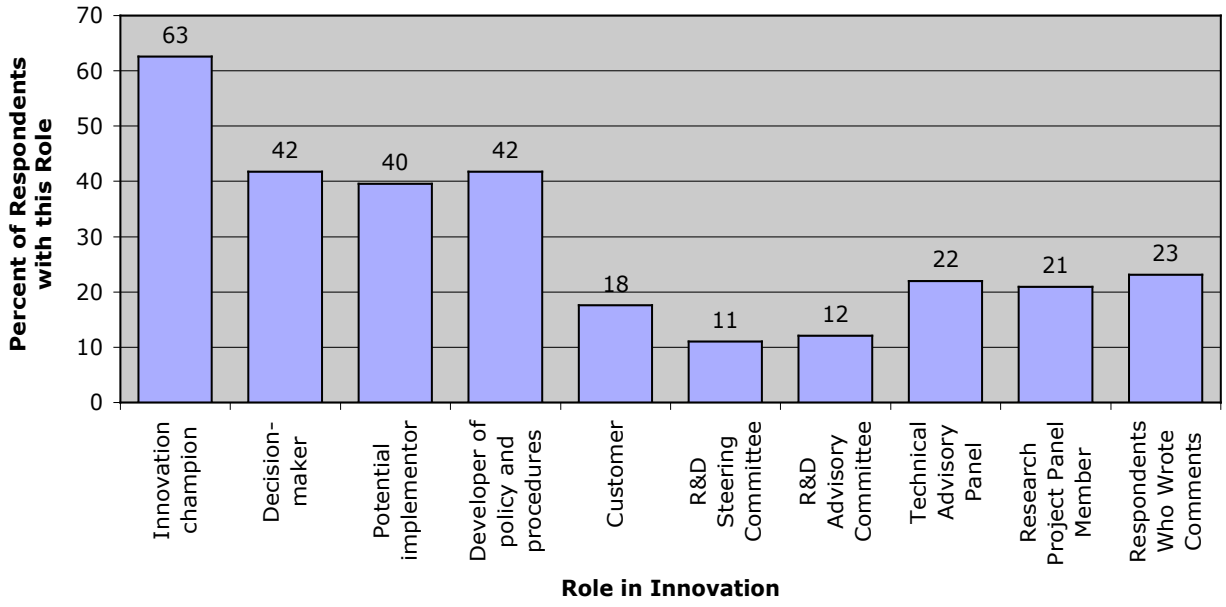

Figure 5. Respondents' roles in the innovation process.

Q7. Rate the importance of the roadblocks to innovation listed below.

The purpose of this question was to determine the degree of importance of each of the ten roadblocks. Respondents' answers will reveal which roadblocks they consider as most serious.

Figure 6 shows respondents' ranking of the ten most common organizational and technical roadblocks to implementing innovation. Results show that both Caltrans practitioners and academic researchers view "*resistance to change*" by a wide margin as the most serious roadblock to innovation, with researchers thinking it is a little more serious (4.8 on average) than Caltrans participants do (4.6 on average). The least significant roadblock to both groups seems to be contracting issues. However, this barrier seems much more significant to Caltrans group, who rated it 3.7, as opposed to the academic group, who rated it 2.9. Caltrans group is much more concerned about this roadblock than researchers because many of Caltrans practitioners are project managers who, naturally, deal more with procurement and contractual problems. Roadblock #7, "no time for innovation," was described by one respondent as "the biggest impediment to implementing new innovations." The same respondent lamented "we do not have the people to spend the time it takes to make it happen. They are, and rightly so, too busy putting out the fires today." Many respondents identified additional roadblocks that they have encountered in their practice. Those are presented later in discussion for Question 10.

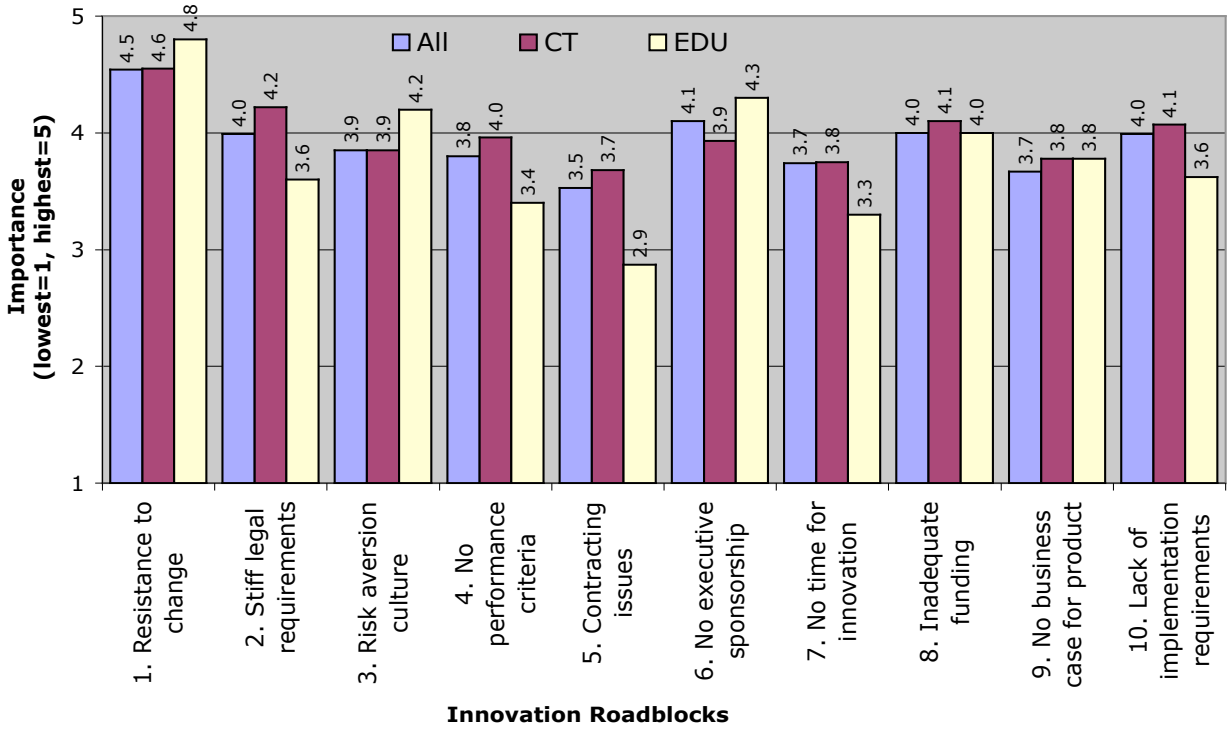

Figure 6. Respondents' ranking of the importance of innovation roadblocks.

Note: Question 9 will be discussed before Question 8 because it deals with institutional barriers. Question 8 will be discussed afterwards.

Q9. Rate the following in terms of their importance as institutional barriers to implementing innovations.

The purpose of this question was to determine which institutional factors respondents believe would most impede innovation.

Figure 7 shows respondents' ranking of six common institutional barriers to implementing innovation. Results show that both Caltrans practitioners and academic researchers view "lack of political will to take on challenge" as the most serious institutional barrier to innovation, with researchers thinking it is more serious and rating this barrier 4.7 on average as compared with Caltrans group, who rated it 4.3 on average. Academic researchers did not seem to consider "diversity of transportation" to be a significant "institutional" barrier, giving it an average rating of 3.2. Caltrans group on the other hand thought it was much more serious, rating it at 4.0. This may suggest that researchers think of transportation more as complex system of road structures and traffic networks that is challenging and exciting to analyze. Caltrans practitioners on the other hand may view transportation more as a system of multiple agencies, jurisdictions with conflicting objectives and competition for control and resources. Resistance to change was rated high in both the institutional and roadblock results.

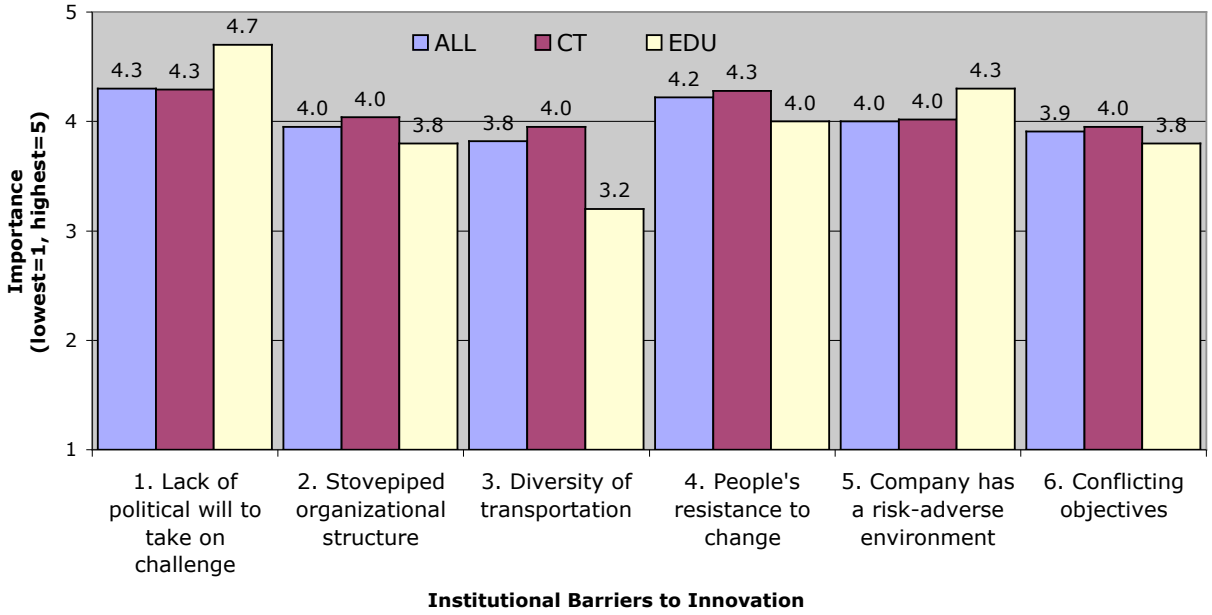

Figure 7. Respondents' ranking of institutional barriers to innovation.

Q8. Rate the implementation boosters that would promote innovation.

The purpose of this question was to determine which factors respondents believe would facilitate innovation and boost the process of implementing innovation.

Figure 8 shows respondents' ranking of the nine most common cited factors that enable and boost the process of implementing new innovations. No one factor was rated significantly better booster. Respondents similarly ranked all nine boosters quite similarly. "Product matches user needs" and "user/customer participation" received the highest ratings with 4.6 and 4.5 respectively. Many respondents discussed ways of boosting innovation in their responses to Question 10.

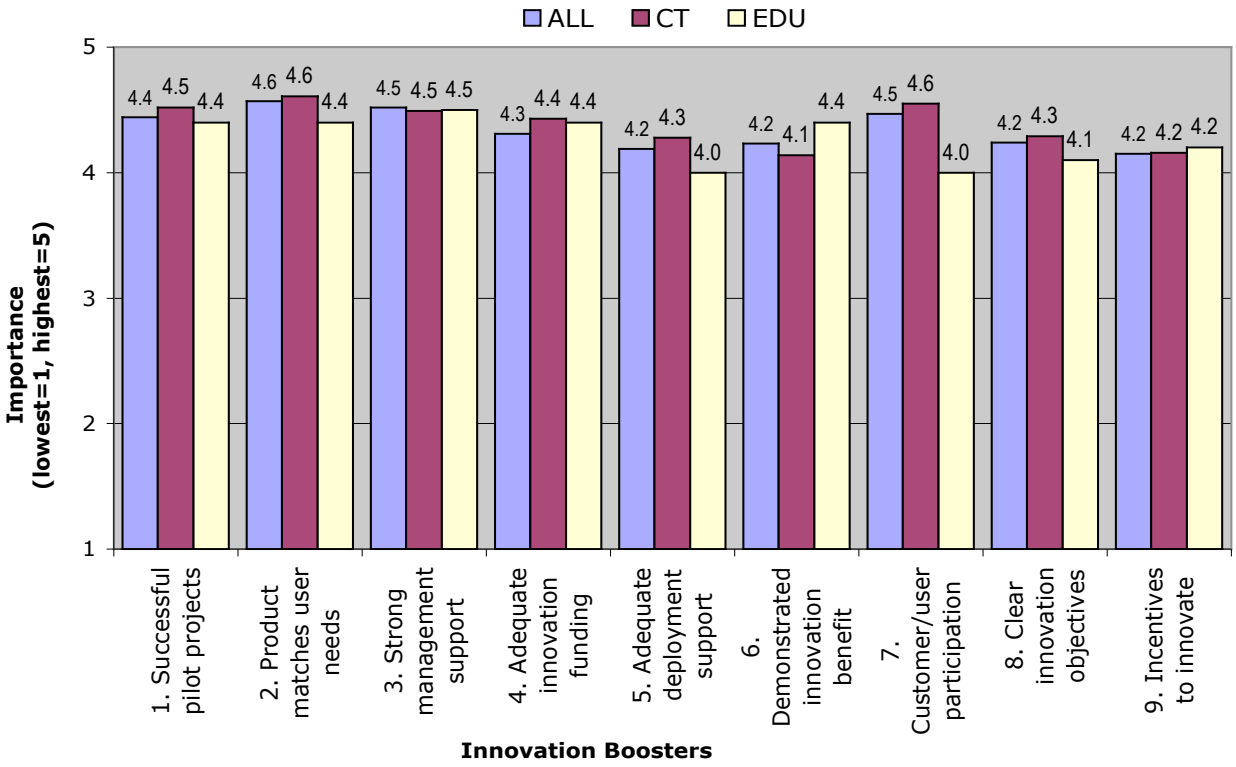

Figure 8. Respondents' ranking of the importance of innovation boosters.

Respondents rated user involvement as an important booster of innovation. The highest rated booster is "product matches user needs," but "customer/user participation" and "strong management support" are also indicators of the desire to have customer directly involved in the research and deployment of innovative products. The high ranking of "successful pilot projects" and "demonstrated innovation benefits" strongly suggest that providing documentation of the benefits and business cases for implementing innovation is also an important innovation boosters. These involving customers and documenting benefits are key elements of system engineering principles that should be considered when planning for producing innovations that become successful product deployments.

Q10. What can be done to improve how innovations are implemented?

This question requested written recommendations from respondents about how to improve the implementation of innovation. It allowed respondents to provide unconstrained comments, suggestions, and recommendations on how to best overcome roadblocks and move the innovation process forward. Almost 60% of respondents (64 people) provided suggestions. These suggestions are discussed under Respondents' Recommendations section below.

RESPONDENTS' RECOMMENDATIONS

All respondents reported high levels of education and extensive experience in the field of transportation research and development. Many respondents have executive-level responsibilities. Suggestions collected through Question 10 were mostly based on personal and professional experience of the individuals. Overall, suggestions centered around seven ideas as presented below. Respondents are either directly quoted with use of quotation marks or paraphrased as carefully and closely as possible.

1) Establish clear direction and procedures for the innovation process

A vast number of respondent comments focused on the need to establish clear direction and procedures for the innovation process, including clear objectives and precise performance measures to evaluate success. One respondent stressed the importance to define what is "new" and what is "innovative" (R85). Another said clear procedures should be created for implementations and marketing (R13), and some respondents recommended to make pilot projects part of the implementation process. Frustration with bureaucracy was evident. The innovation process should be streamlined so that there are fewer barriers holding up innovation (R76). "The FSR [Feasibility Study Report required for implementation of innovations at Caltrans] process and requirements are mind-boggling and in need of streamlining as well" (R76). Executive leaders must "institutionalize" the culture of encouraging innovation by integrating it into work plans and incorporating it into the regular performance evaluations of the organization and its managers (R40). One respondent's experience is that most innovations stop at the recommendations level in government and there are not good implementation plans to carry out the recommendations make them permanent or institutional (R14). The same respondent further cautioned that "Too often things are attached to a person and when that person moves on and so does the innovation." (R14). The implementation of innovation should be mandated in order to carry innovation to fruition (R23).

2) Improve communications

One respondent emphasized "Communicate, communicate, and communicate." (R25). Make sure that everyone with an interest in the potential innovation gets a chance to provide input and to question (R25). A university research executive suggested connecting the organization [say Caltrans] more closely with researchers and innovators (R67). A project manager would mandate customer participation in project progress and meetings (R84).

3) Secure executive sponsorship and management support

There was a universal consensus that strong management support for innovation is indispensable. "There is no substitute for leadership with vision and practical, focused follow-through," one respondent wrote (R#40). Innovation begins with executive-level commitment and development of a work environment that embraces innovation (R38). Upper management

support and encouragement is required (R24). Innovation needs strong executive support & successful pilots/demos (R39). There is a need for strong executive mandate and adequate funding of demonstration programs (R81). While executive-level support is important, they need to leave the implementation to the experts. Leaders should lead, not manage (R35). Finally, top leadership has to make innovation a priority and then hold people accountable (R32).

4) Empower people and find champions for each innovative idea/project

Innovation champions are needed in the innovation policy and procedures area. Otherwise, innovations will fall flat or will not reach full potential (R6). Many respondents suggested that research staff "needs to be empowered to accomplish innovation." (R46). It is necessary to have champions at high-levels in order to create a culture for innovation in an organization as well as product-level champions to overcome resistance to change (R17). A university professor and a director of a university transportation center said: "Give people some freedom to try new things." (R60). A Caltrans project manager suggested to give ownership of each innovation project to a small team with management backing (R95). One respondent pointed out the role of the individual in innovation and cautioned that, "if the person who is championing the change is not liked in the organization, the change may be overlooked." (R#6)

5) Create incentives for innovators

Many respondents argued for increasing opportunities for innovative ideas. Creating incentives was advocated by both university researchers and project managers. "More ideas portend higher probability of innovation which may be implemented" said a university researcher (R91). A senior electronics engineer would reward innovators and reward those in management who are willing to take reasonable risk when the potential advance is significant (R94). A senior transportation engineer would encourage more innovative research work by staff by reducing administrative workload demands (R100).

6) Demonstrate the benefits of innovation

Many respondents emphasized the importance of ensuring that end users have clear understanding of the advantage of innovation (R89). The benefits of the concept must be proven to satisfy the real user needs (R36). Innovation advocates and end-users must have clear understanding of the problem and value added by innovation (R53). The importance of an innovation must be clarified up front to all stakeholders (R62). Case studies should be used to show how other state agencies have implemented an innovation and show how it has improved their business (R77).

7) Manage risk and change

Surprisingly, many respondents with executive authority confronted the need to take reasonable risk head on. One asked to "demystify risk" because sometimes "it is riskier not to act." (R52). Another said one must "accept certain amount of risk to compensate for high payoff." (R68). One acknowledged that the core issue is the "risk-averse culture," the general lack of positive reinforcement to try something new, and the "penalties" if you break the mold and fail (R87). One executive cautioned, however, to be realistic and not expect the organization to always absorb the cost/effort to innovate (R78). One respondent believed that people, users, and even institutions that normally are reluctant to change would eventually welcome "good" changes that make life easier (R109).

CONCLUSIONS

This research showed that all transportation professionals surveyed, whether they are rank-and-file or executives, planners or engineers, in the private or public sector, practitioners or educators from across the country almost unanimously believe that innovation is "important" or "very important." Academic researchers seem to believe more in "revolutionary" rather than "evolutionary" innovation. Real-world practitioners on the other hand believe in gradual, sustaining, non-disruptive innovation. The authors see no conflict here. Researchers need to be adventurous, knowledge seekers. On the other hand, engineers have to build safe, reliable systems that take time and effort to design, build, and test. Planners need to plan in an evolutionary manner that takes into consideration market demand and socio-economic and political factors. Smart confluence of both approaches will ensure that exciting innovations get created and implemented.

Respondents nearly collectively recommended seven major actions to help the process of innovation: 1) establish clear direction and procedures for the innovation process, 2) improve communications; 3) secure executive sponsorship and management support; 4) empower employees and find champions for each innovation, 5) create incentives for innovators; 6) demonstrate the benefits of innovation, and 7) manage risk and change.

Finally, the research showed that "resistance to change" and "lack of political will" are among the most serious barriers to innovation. The highest-rated enabler of innovation was "product matched user need." It was also evident that innovation, whether disruptive or sustaining, requires champions of innovation at all levels of the organization to be successful. It was evident that managing risk and change is critical for the success of innovation. In the public sector, most failures are highly publicized and criticized. A single innovation failure can outstand, outtalk, and overshadow dozens of successful ones. Therefore, creating the ability to take calculated, reasonable risks is required at all public agencies in the transportation sector.

TABLE II Position and State of Referenced Respondents

R#	Position	State
6	Caltrans Branch Chief	California
13	Pavement Researcher	California
14	Research Analyst	California
17	Research Engineer	Kansas
23	State Programming Engineer	Wyoming
24	Director, Research Services	Minnesota
25	Research Director	Alberta, Canada
27	Research Unit Manager	Oregon
32	Organizational Results Director	Missouri
34	Director, Research and Technology Implementation	Texas
35	Director, Research and Development	New York
36	Director, Transportation Research Center	Kentucky
38	Director, Transportation Research	Maine
39	Research Program Development Manager	Pennsylvania
40	President and CEO, a California company	California
46	Caltrans Deputy District Director	California
52	Caltrans Division Chief	California
53	Caltrans Office Chief	California
60	Professor, Director, Univ. Transportation Center	California
62	Transportation Planner	California
67	Director, Institute of Transportation Studies	California
68	Professor	California
76	Caltrans Office Chief	California
77	Civil Engineer	California
78	Caltrans Division Chief	California
81	Executive Director, University Transportation Inst.	California
84	Transportation Engineer	California
85	Caltrans Division Chief	California
87	Caltrans Deputy District Director	California
89	Sr. Transportation Engineer	California
91	Transportation Safety Research Program Leader	California
94	Sr. Electronics Engineer	California
95	Senior Research Engineer	California
100	Sr. Transportation Engineer	California
101	Sr. Transportation Engineer	California
109	Sr. Transportation Engineer	California
109	Sr. Transportation Engineer	California

ACKNOWLEDGEMENTS

The authors wish to thank the following individuals for their valuable contributions to this study: Dr. Peter Haas, Director of Education at Mineta Transportation Institute at San Jose State University; Dr. Brahm Ravani, Director of the Advanced Highway Maintenance and Construction Center at UC Davis; Dr**.** Genevieve Giuliano, Director of METRANS at the University of Southern California.

REFERENCES

1. Research and Technology Coordinating Committee. The Federal Role in Highway Research and Technology Special Report No. 261, Transportation Research Board, National Research Council, National Academy Press. Washington, DC, 2001.

2. Hikichi, Lynda K. and Beimborn, Edward A.. "Examination of Process of Innovation at Transit Systems," *Transportation Research Record 1986,* Washington, D.C. 2006.

3. AlKadri, Mohamed, Benouar, Hamed, and Tsao, H.-S. Jacob. "Intermediate Automation Concepts for Incremental Deployment of Automated Highway Systems," *Transportation Research Record 1651,* Washington, D.C. 1998.